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(With Five Plates)

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THE JAW OF THE PILTDOWN MAN

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About three years ago Mr. Charles Dawson found the right half of an ape-like jaw in undisturbed material five feet below the level of the surrounding country in a gravel pit at Piltdown, Sussex, England. It lay in a depression at the bottom of the third and lowest stratum of the deposit, a band eighteen inches thick consisting of "dark brown ferruginous gravel, with subangular flints and tabular ironstone, pliocene rolled fossils .... 'eoliths,' and one worked flint" (Dawson and Woodward, 1914, p. 83). This third layer is supposed to be "in the main composed of pliocene drift, probably reconstructed in the pleistocene epoch" (Dawson and Woodward, 1914, p. 85). Within a yard of the same spot, and at precisely the same level, Dr. A. Smith Woodward later dug out a small piece of a human occipital bone. From this pit, and presumably from about the same part of it, other fragments were secured. They represent about half of a human braincase, a pair of human nasal bones, and a simian canine tooth; also teeth of beaver, horse, hippopotamus, rhinoceros, and two kinds of elephant. The human and simian remains were regarded by their discoverers as parts of one individual. On the basis of this assumption, though before the canine tooth and the nasal bones had been found, Dr. Woodward established a genus *Eoanthropus,* characterized by the combination in one skull of a human braincase and a completely ape-like jaw (Dawson and Woodward, April 25, 1913, p. 135).

Few recently discovered fossils have excited more interest than the "Dawn Man of Piltdown," and few have given rise to more discussion (see bibliography at end of this paper). Deliberate malice could hardly have been more successful than the hazards of deposition in so breaking the fossils as to give free scope to individual judgment in fitting the parts together. As a result no less than three restorations of the braincase already exist (see Gregory, 1914, fig. 9), while the canine tooth has been assigned to the right lower mandible and the left upper jaw. The estimates on the capacity of the braincase range from 1,070 to 1,500 cubic centimeters. While there is no doubt that

the braincase, whatever its exact size, represents a member of the family *Hominidæ,* there is wide difference of opinion as to the possibility of joining it with the mandible as parts of one skull. One author regards "this association of human brain and simian features" as precisely what he had anticipated (Smith, 1913, p. 131), while another says that it seems to him "as inconsequent to refer the mandible and the cranium to the same individual as it would be to articulate a chimpanzee foot with an essentially human leg and thigh" (Waterston, 1913, p. 319). I cannot find, however, that anyone has yet definitely identified the jaw as that of a member of an existing simian genus, or that any zoologist has attempted a detailed comparative study of this part of *"Eoanthropus."* Dr. Woodward, who regarded the jaw as "almost precisely that of an ape," compared the specimens with young and adult chimpanzee only, while Dr. Gregory chose for his simian standard a female orang. Neither appears to have examined any considerable series of jaws of great apes.

Dr. Aleš Hrdlička has submitted to me a set of casts of the Piltdown fossils, and has suggested that I compare the mandible with the jaws of *Pongidæ* in the United States National Museum. This material includes the mandibles of 22 chimpanzees, 23 gorillas, and about 75 orangs. I have also had access to the series of human skulls in Dr. Hrdlička's custody. Study of these specimens, together with the general collection of primates in the museum, shows that the characters of the mandible and lower molars throughout the order *Anthropoidea* are much more diagnostic of groups than has hitherto been realized. It also convinces me that, on the basis of the evidence furnished by the Piltdown fossils and by the characters of all the men, apes, and monkeys now known, a single individual cannot be supposed to have carried this jaw and skull.

Analysis of the Published Opinions that the Jaw and Skull Were Parts of One Animal

The reasons that have been given for associating the jaw with the skull as parts of one animal are of three kinds: distributional, geological, and anatomical. They may be briefly reviewed before the characters of the fossil are taken up in detail.

The distributional evidence is negative. It is thus summarized by Dr. Gregory (1914, p. 194):

> The suggestion that while the braincase was human, the lower jaw belonged to another creature, an ape, is not in harmony with what is already known of the fauna and climate of Europe during pleistocene times. Thousands

of mammalian remains of pleistocene age have been discovered in the glacial and interglacial deposits of England and the Continent, but in this highly varied fauna the anthropoid apes have always been conspicuously absent, and there is no reliable evidence that any of the race ever lived in England during the pleistocene epoch.

In this statement two facts are not given their due weight; first, that the paleontological record is so fragmentary that unexpected discoveries need cause no surprise, and second, that a tooth from Taubach, Saxe-Weimar, described and figured by Nehring in 1895 as essentially similar to the first lower molar of a chimpanzee, had already indicated the possible occurrence of the genus *Pan* in Europe during the pleistocene age.

The geological evidence in favor of intimate association of the jaw and braincase is merely that the bones were found close together, at one level, and in a uniform condition of fossilization and water-wearing. These circumstances would give additional reasons for associating remains that presented no zoological difficulties; but when there is obvious incompatibility they do not furnish serious elements of proof. Mr. Dawson's remarks about the deposition of the other mammalian remains found in the same gravel apply with equal force to the skull and the jaw of *"Eoanthropus"*: the mere fact that they lay near each other means little. He says (Dawson and Woodward, 1913, p. 151):

> The occurrence of certain pliocene specimens in a considerably rolled condition, while the human remains bore little traces of rolling, suggested a difference as to age, but not to the extent of excluding the possibility of their being coeval. The rolled specimens might have entered the stream farther up the river than the human remains, and thus might have drifted into the hole, or pocket, in the river bed, where they were found, during the same age but in different condition . . . . It must be admitted that any attempt to fix any exact zoological date for specimens found in a gravel-bed is fraught with difficulties.

The anatomical reasons are (a) that the jaw "corresponds sufficiently well in size to be referred to the same specimen [as the braincase] without any hesitation" (Dawson and Woodward, 1913, p. 129); (b) that the measurements are "on the whole nearer to those obtained from early human jaws than to those of full-grown apes" (Gregory, 1914, p. 195); (c) that the molars recall human rather than simian teeth in their flattened, worn surfaces and their very thick enamel; and (d) that the condyle, or what remains of it, is more like the average human type than that of an ape. As to the relative size of the jaw and braincase nothing very definite can be said except that

no proof is afforded. To Dr. Woodward the parts appeared to present no discrepancies as to size; but to others who have examined the casts the jaw seems to be too lightly built to correspond with the massive cranial bones. A mandible as heavy as that of the pleistocene *Homo heidelbergensis* would probably be in due proportion; but the Piltdown jaw is even less robust than in well developed recent men. As regards actual dimensions the table on page 20 shows the wide divergence of the Piltdown jaw from both *Homo sapiens* and *H. heidelbergensis,* and its essential agreement with that of recent chimpanzees. Comparisons with *Gorilla* and *Pongo* are not necessary. About the teeth Dr. Woodward went so far as to say: "such a marked regular flattening has never been observed among apes, though it is occasionally met with in lower types of men" (Dawson and Woodward, 1913, p. 132). Yet I find that among nine chimpanzees with teeth at nearly the same stage of wear as in the type, the smooth condition shown by the fossil is closely approached by one individual and exactly matched by another (No. 84655, pl. 1, fig. 1, from cast, and pl. 2, fig. 1″, from actual specimen). While the thickness of the enamel is usually greater in *Homo* than in *Pan,* individual variation in both genera is sufficient to make this character, taken by itself, of little diagnostic value. The cast and Dr. Woodward's figures indicate that the Piltdown teeth have enamel differing in no essential feature from that of *Pan* No. 84655 (compare pl. 2, figs. 1″ and 2″). As regards the mandible of the fossil it must be remembered that the articular process is worn off to the level where it begins to widen and thicken to form the base of the condyle. From the characters of the part which remains Dr. Gregory reasoned that the condyles were "more slender, less expanded transversely, and supported by more slender pillars of bone" than in the great apes, features which would make the jaw "more like the average human type" (1914, p. 195). This conclusion may be true when the only alternatives considered are *Homo* and *Pongo,* but it does not hold good when the Piltdown jaw is compared with those of *Homo* and *Pan.* The articular process near level of fracture shows more lateral compression than I have been able to find in any specimen of *Homo,* and there is no indication of the deep concavity beneath the inner two-thirds of anterior edge of condyle which is a conspicuous feature of this region in *Homo* as compared with all the great apes. While the outer border of the fracture is unusually long relatively to the posterior and inner borders of the same region as seen in most specimens of *Pan,* the conditions in the Piltdown jaw would be almost exactly

reproduced by similar mutilation of the articular process of No. 174699, an adult female chimpanzee from French Congo. The arguments from anatomy, like those from geology and geography, are thus seen to have little force.

Mandibular Characters of the Anthropoidea

Before trying to decide how much importance should be assigned to the peculiarities of the Piltdown jaw it is necessary to understand the more conspicuous mandibular characters of the *Anthropoidea.*

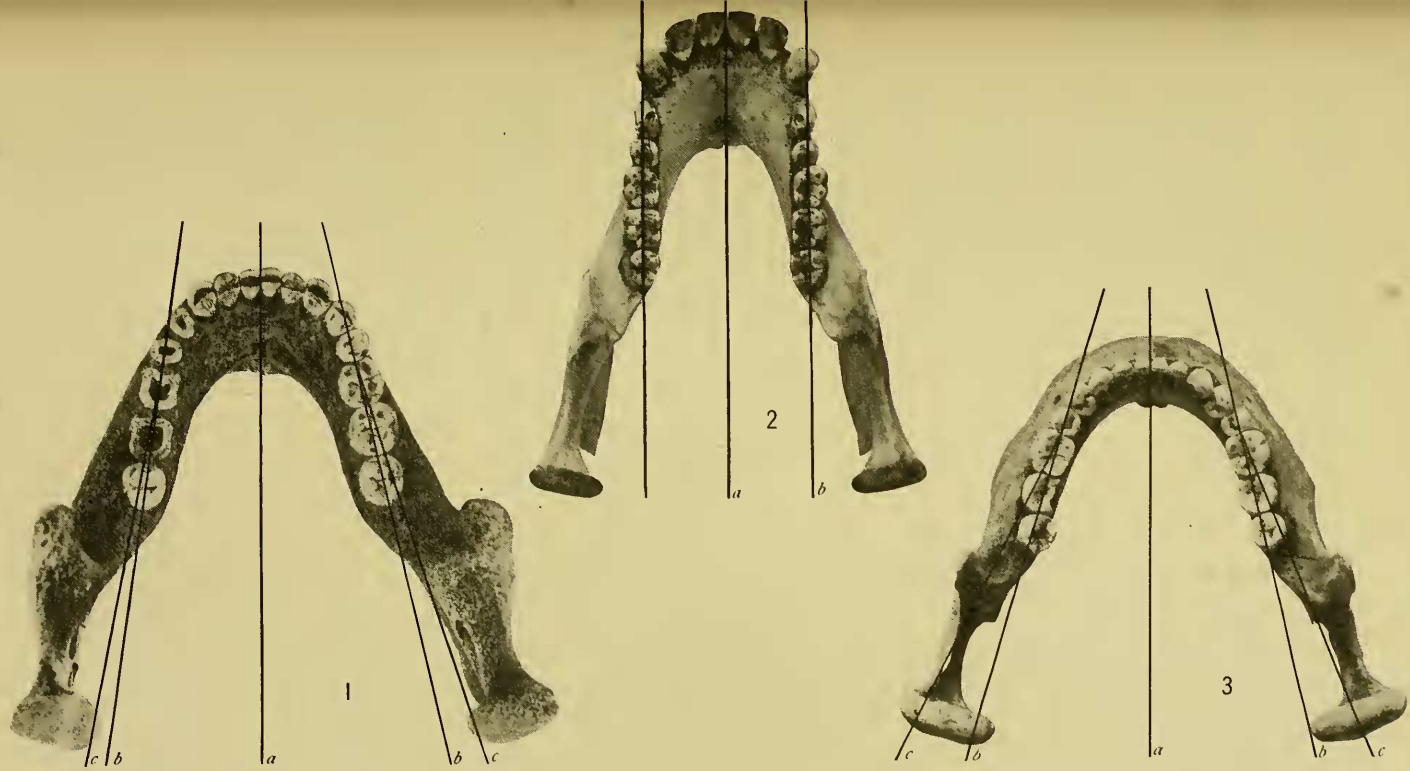
In the *Hominidæ*[1] as in all other *Anthropoidea* the mandibular halves become completely ossified at the symphysis soon after birth. This character distinguishes members of the order from the recent *Lemuroidea,* in all of which the halves remain distinct. Two main peculiarities of the lower jaw and its toothrow separate the *Hominidæ* from other *Anthropoidea* and especially from the great apes. The two halves of the jaw together form a horseshoe-like arch (text fig., 1 and 3, and pl. 3), so broadly rounded in front that the width between the anterior molars is decidedly greater than the distance from the first molar to the symphysion, and so widely open behind that the distance between the condyles (outer borders) is conspicuously greater than that from condylion to symphysion. In other members of the order the arch is so narrow that the distance between the anterior molars never exceeds that from first molar to the symphysion, and the distance between the condyles rarely if ever equals that from condylion to symphysion (text fig., 2, and pl. 4). The toothrow in the *Hominidæ* is narrowed and weakened in front of the molars, the change taking place abruptly with posterior premolar. Each premolar is single rooted, and the crown-area is less than half that of the first molar. The canine never projects conspicuously above the general level of the other tooth summits; its size, form and function are essentially incisor-like. Among the great apes the robust character of the toothrow is carried forward through the large, double-rooted premolars to the strongly functional canine, the point of which rises in males conspicuously above the general level of the other teeth. Together with its anterior weakening the toothrow as a whole is characterized in the *Hominidæ* by a widely arched form corresponding to that of the jaw. The inward curve on each

[1] Including the various living species of *Homo* and the pleistocene *H. neanderthalensis* King and *H. heidelbergensis* Schoetensack, but excluding, as members of the family *Pongidæ,* the genera *Pithecanthropus* Dubois and *Sivapithecus* Pilgrim.

side begins with the molars, while in the great apes it begins with the premolars or canines. A line joining the middle of posterior border of m_2 with the middle of anterior border of m_1, will, if continued forward in front of incisors, converge rapidly with the sagittal line similarly extended (text fig., 1 and 3, b). In the great apes and in most of the monkeys except certain smaller South American forms a line passing through middle of posterior border of m_2 and middle of anterior border of m_1 is essentially parallel to the sagittal line (text fig., 2, b). In the *Hominidæ* the inward curve of the tooth-row normally begins with the first lower molar. The axis of this tooth prolonged backward (text fig., 1 and 3, c) diverges rapidly from a line parallel to the sagittal plane and crosses the posterior border of m_2 on outer side of middle; continued still further it passes through the condyle. That of the second tooth similarly prolonged, while diverging slightly from a line parallel to the sagittal plane, passes considerably to inner side of condyle. In all living genera of great apes and in the fossil *Propliopithecus, Dryopithecus,* and *Sivapithecus* the axes of the two teeth (text fig., 2, b) lie in one line essentially parallel to the sagittal line and passing further to inner side of condyle than is the case with the axis of m_2 in the *Hominidæ*. The symphysial region in the *Hominidæ* seldom extends conspicuously behind the level of the incisors, and never bears a marked concavity on its posterior border for insertion of the lingual muscles; in other primates it always extends conspicuously behind level of incisors and it usually bears a marked concavity on its posterior border. The mylohyal ridge is well developed in the *Hominidæ,* but is barely indicated in monkeys and apes.

While sharing those general peculiarities which distinguish other primates from the *Hominidæ,* the three[1] genera of living great apes are readily separable from each other by the details of their mandibular structure. In *Pan* and *Pongo* the digastric muscle is inserted along the lower border of the mandible, rarely extending forward

[1] In the most recent complete work on the order, Elliot's "Review of the Primates," New York (1912), June, 1913, four genera are recognized: *Pongo* Lacépède for the orangs, *Gorilla* I. Geoffroy for the gorillas, *Pseudogorilla* Elliot (l. c. vol. 3, p. 224) for an animal supposed to be the *Gorilla mayema* of Alix and Bouvier, and *Pan* Oken for the chimpanzees. The genus "*Pseudogorilla*" was based on two specimens of true *Gorilla,* an immature male with all the teeth in place but with the basal suture open and the temporal ridges separate (l. c. pl. 32), and a mature female with the basal suture closed and the temporal ridges joined (l. c. pl. 33). Three valid genera are thus left in the group.



TEXT FIG.—Lower jaws (about half natural size) of: 1, *Homo heidelbergensis* (after Schoetensack): 2, *Pan* sp. (No. 176226, southern Kameroon); and 3, *Homo* sp. (No. 278783, Urga, Mongolia). *a* sagittal line, *b* line joining middle of anterior border of m_1 with middle of posterior border of m_2, *c* axis of m_1. In No. 2, *c* is not different from *b*. The specimen figured as No. 3 was selected to show wide divergence of *b* and *c* from *a*; in many recent individuals the conditions are essentially as in No. 1. Anomalies are not infrequent.

beyond the extreme posterior edge of the bone. This region of attachment forms a thin, sharply-defined ledge beneath the pit in which the other tongue-muscles are inserted. While the lower border is essentially alike in the two genera the pit is deeper and narrower in *Pan* than in *Pongo* and its upper border is usually well-defined by an abrupt convexity in the posterior profile of the symphysis; the hinder margin of this convexity lying at level of canine or anterior premolar. In both genera the region of temporal muscle-insertion is characterized by the presence of a distinct and narrow ridge curving upward from behind the alveoli and extending to or above the middle of the coronoid process. While they thus agree in certain characters the two genera differ from each other in the form of the symphysis, which, like the entire horizontal ramus, is deeper in *Pongo* than in *Pan*. The base of the articular process in *Pan* is strengthened by a conspicuous ridge extending obliquely downward on the inner side of the mandible. In *Pongo* this ridge is barely indicated. Below the ridge in *Pan* a distinct groove extends upward and backward from the dental foramen; this is scarcely visible in *Pongo*. Turning to *Gorilla* it is seen that the digastric muscle pushes conspicuously forward under posterior border of mandible, so that the ledge beneath the pit is broadly rounded off. The pit is small and ill-defined, and the region which it occupies is carried so far backward by the very gradually sloping symphysis that its upper margin lies at level of posterior premolar. In the region of temporal muscle-insertion the ridge extending upward toward the coronoid process is usually deflected forward below the base of the process. The dental foramen and the region behind it are about as in *Pongo*. The strengthening ridge of articular process is more evident than in *Pongo* but less defined than in *Pan*.

The lower molars in the living primates represent three main types of structure, peculiar respectively to: (a) the American monkeys, (b) the *Hylobatidæ*, great apes,[1] and *Hominidæ*, and (c) the remaining Old World forms. The first type (most clearly shown by *Alouatta*) is essentially that of the more primitive lemur molars (as in *Propithecus*) modified by partial or complete suppression of the paraconid and by various degrees of flattening out of the original triangles, with no addition of new elements. In the second type the paraconid is absent (sometimes a faint trace in *Gorilla*) and there is normally a well-developed talonid. The posterior half of the crown is, as in the first type, basin-shaped; and any transverse ridge which

[1] Also in the extinct genera *Dryopithecus* and *Sivapithecus*.

it may bear extends obliquely between hypoconid and talonid. In the third and most specialized type the paraconid is absent, the talonid is not well developed except in m_3, and the posterior half of the crown is not basin-shaped. The region occupied by the hollow in the other types is here filled by the bases of the hypoconid and entoconid. Usually the bases of these cusps join to form a high, squarely-transverse ridge.

While the great apes and the *Hominidæ* agree in the fundamental structure of their lower molars each genus shows obvious characters of its own. In *Gorilla* the crowns are low and the cusps high, subterete and more conspicuous than in any of the others. The cingulum on anterior border of m_1 sometimes bears a nodule which may be the last remnant of the paraconid, a character which I have found in this genus only. The talonid of m_3 is very distinct, often larger than the hypoconid and often connected with the hypoconid by a rudimentary oblique transverse ridge. The cingulum at the postero-internal border of crown occasionally bears a minute cusp, while sometimes it is completely transformed into a well-developed single or double cusp. The secondary folding of the enamel is evident, but not sufficiently developed to obscure the plan of cusp-arrangement. A low supplemental cusp is sometimes present between the protoconid and the hypoconid. In *Pan* the depressions between the cusps are not so deep as in *Gorilla,* so that the crowns appear to be less brachydont and the cusps less terete and less conspicuous. The talonid in m_3 is less developed than in m_1 or m_2, not larger than the hypoconid. Cingulum of postero-internal border often so thickened as to form a supplemental cusp. The secondary folding of the enamel is more evident than in *Gorilla;* it tends to obscure some of the details of the cusp-arrangement. In *Pongo* the cusps take the form of ridge-like elevations at the extreme border of the shallow depression which occupies most of the surface of the crown. The talonid is well developed but is somewhat obscured by the flattening common to all the cusps and by the extremely conspicuous and complicated secondary enamel folding which covers almost the entire surface of the teeth except the summits of the main cusps. In the *Hominidæ* the crowns are slightly less brachydont than in any of the genera of great apes; and the cusps are less distinctly outlined by intervening depressions. Viewed from above they are seen to be less squarely truncate, so that each tooth comes less broadly in contact with the one in front of it (compare pls. 3 and 4). This rounding off at the sides takes place in front at expense of both protoconid and metaconid. There is a similar reduction at the posterior border,

making the entire tooth shorter and more nearly circular in outline than in any of the great apes. The posterior shortening occurs in the region occupied by the talonid and the postero-internal cingulum. The talonid is therefore less constantly present than in the great apes, though it appears to occur normally in m_1 (where it is sometimes divided into two cusps), often in m_3, and less frequently in m_2; rarely it is present in all three teeth. The postero-internal cingulum is seldom a noticeable element. The secondary enamel folding though present is less evident than in any of the great apes. In general the lower molars of the *Hominidæ* may be described as like those of *Pan* but with higher crowns, lower, broader, less sharply-marked-off cusps, less wrinkled enamel, and more rounded-off anterior and posterior borders, the rounding-off behind practically eliminating the postero-internal cingulum and decidedly reducing the talonid or "fifth cusp" (compare pls. 3 and 4).

Two main facts are now evident: that among the living and recently extinct great apes and *Hominidæ* (a) all the more important features of each group remain constant in such widely separated forms as *Homo sapiens* and *H. heidelbergensis*[1] on the one hand and *Pongo, Gorilla* and *Pan* on the other, and (b) each known genus is sharply differentiated from all the others by characters visible in the Piltdown jaw.

Comparison of the Piltdown Jaw and Teeth With Those of Other Members of the Order

The Piltdown jaw (pl. 1, fig. 2, and pl. 2, fig. 2) admittedly differs from every known mandible of living or extinct members of the family *Hominidæ*. Although broken away a little to the right of the symphysis, it has an abrupt anterior bend which is exactly that of a great ape. The symphyseal region extends conspicuously behind the level of the incisors. The region of the mylohyal ridge is smoothly rounded. The two molars (pl. 2, fig. 2) show no indication of the beginning of a curve in the toothrow. The main axis of the first tooth is continued backward by that of the second in a line passing as far to inner side of condyle as in the *Pongidæ*. In front of the first molar the entire hinder border of the alveolus of pm_4 is plainly visible. It shows that the missing tooth was fully as large as in the great apes

[1] Regarded as a distinct genus by at least two authors: Bonarelli, Revista Ital. di Paleont., Perugia, vol. 15, p. 26, March 15, 1909 (*Palæanthropus*); and Ameghino, An. Mus. Nac. de Buénos Aires, vol. 19 (ser. 3, vol. 12), p. 195, July 27, 1909 (*Pseudhomo*).

and that the toothrow did not become abruptly weakened at the point where this conspicuous change takes place in all known *Hominidæ*. The molars are distinctly less hypsodont [1] than in recent or pleistocene *Hominidæ*. On the outer surface of each tooth there is a trace of a deep sulcus extending downward between the protoconid and the hypoconid nearly to the lower border of the enamel in a manner rarely seen in *Homo* (compare pl. 3 with pl. 2, figs. 2″ and 4) but constant in *Gorilla, Pan* and *Pongo*. In each tooth there is a large talonid and a postero-internal cingulum, better seen in the photograph (pl. 2, fig. 2″) than in the cast (pl. 2, fig. 2′). The anterior border of the crown is squarely truncate; and the general outline of each tooth is unlike that known in any recent or fossil man.

Though its general characters are the same as those of all the living great apes, the Piltdown jaw is readily distinguishable from jaws of *Pongo* and *Gorilla*. There is no trace of the deepening of the horizontal portion of the mandible characteristic of *Pongo,* nor do the teeth show any indication of ridge-like cusps and heavily wrinkled enamel. Enough of the symphyseal region remains to prove that this did not extend backward as in *Gorilla;* while the teeth differ at least as widely from those of *Gorilla* as from those of *Pongo*. Comparison with the mandible of *Pan* brings out no such discrepancies. On the contrary there is agreement in all the features which distinguish *Pan* from the two other genera: in depth of horizontal portion, in form of symphysis, in the ridges on inner side of ascending ramus, and in the peculiarities of dental foramen and the groove behind it. On plates 1 and 2 the Piltdown jaw is compared with casts of the mandibles of two African chimpanzees mutilated in as nearly as possible the same manner. It will be seen that the main peculiarities of the fossil, apart from the large teeth and robust horizontal shaft, lie within the limits of variation shown by these two African specimens. In another African specimen (No. 174710, pl. 5, fig. 2) the depth of shaft as well as that of the ascending branch is essentially equal to that in the fossil (see table of measurements, p. 20). Further details of variation in the mandible of recent chimpanzees are shown in plate 5. The teeth resemble those of certain living chimpanzees in structure, agreeing in all essential features with those of Pan No. 176226 from southern Kameroon (compare pl. 2, figs. 2″ and 4; allowances must be made for the different degree of wear in the two sets of teeth, and for

[1] In the cast and in the photograph (Woodward, 1915, pl. 4); in the original figure (Dawson and Woodward, 1913, pl. 20) the crowns are represented as essentially human in height.

the fact that the enamel is absent from the antero-internal corner of m_1 in the recent specimen). Their size is greater in proportion to that of the jaw than in any recent material that I have seen. From modern African specimens of *Pan* the Piltdown jaw differs therefore in mere details of proportion and in the actual size of the molar teeth.

The canine tooth found in the Piltdown gravel did not form part of the remains on which the genus "*Eoanthropus*" was based. Yet its interest is so great that it deserves special attention. Of this tooth Dr. Woodward says: it "obviously belongs to the right side of the mandible . . . . and its worn face shows that it worked with the upper canine in true ape fashion" (1913: Nature, p. 110, Geol. Mag., p. 432), while Dr. Gregory remarks: "Its resemblances are on the whole closer to the left upper canine." Boule (1915), however, leaves the tooth in the lower jaw without comment. As "the enamel on the inner face of the crown has been completely removed by mastication" (Dawson and Woodward, 1914, p. 87) and the worn area is a wide, shallow concavity directly backward and inward, there is no reason to doubt the correctness of the second view. Such mechanical interrelation of the teeth as would produce a worn surface of this kind on a lower canine is not only unknown among primates, but I have been unable to find any mammal with the upper and lower teeth so arranged that it could exist. A concavity on the inner aspect of the lower canine may be present, as in adult *Propithecus* or in the milk tooth of *Homo,* but not as the result of gouging out by an upper tooth. The fact that its concave surface is worn therefore removes all significance (Dawson and Woodward, 1914, p. 91; Woodward, 1915, p. 23) from the superficial resemblance of the Piltdown tooth to the lower milk canine of man. In all the living great apes the postero-internal surface of the lower canine is convex (see pl. 4, and Woodward, 1915, fig. 8A as compared with fig. 8B). The worn area normally appears first at the summit of the tooth, then extends down the postero-internal limb of the convexity; later it may spread to the antero-internal surface, and in aged individuals may reduce the tooth to a flattened stub. No matter how long a lower canine may have been in use it never assumes the form seen in that of "*Eoanthropus,*" nor does it lose all trace of the original convexity of its inner portion. The upper canines, on the other hand, are normally worn away over exactly the same area as in the Piltdown tooth. Among the living great apes, while there is much individual variation in size and form, the canines are larger and higher-crowned in males

than in females. Comparison of the Piltdown tooth with those of males of all three genera and of females of *Gorilla* and *Pongo* show numerous and striking discrepancies which need not be detailed here. On comparison with the left upper canine of adult female *Pan,* however, no such discrepancies are found. The cast of the tooth almost fits the left alveolus of No. 174700, an adult female chimpanzee from French Congo. Its greater size and straighter, more compressed root prevent its taking a wholly natural position in the socket; but when as nearly as possible in place it is in all important respects symmetrical with the canine of the right side and with the cheek-teeth of the left series. The only characters by which I am able to distinguish it from the corresponding tooth of adult female recent chimpanzees are the slightly greater size, the less backward-bent extremity of root, and the greater area and deeper concavity of the worn region on postero-internal aspect of crown. The distinction of root from crown is not so well marked as in recent teeth, but this circumstance is probably due to the incomplete condition of the enamel which Dr. Woodward (Dawson and Woodward, 1914, p. 87) has described.

Incompatibility of the Piltdown Jaw and Skull

Discussion of the relationships of the man represented by the Piltdown braincase to the various living and extinct species of *Homo* does not come within the scope of this paper. Certain characters of the skull-fragments are, however, of special importance in connection with the supposed association of the jaw with those remains.

The occipital bone has been said to approach "a lower [than typically human] grade . . . . in the attachment for the neck" (Dawson and Woodward, 1913, p. 132). On comparing it with a few dozen recent human skulls taken at random from the series in the National Museum I find that its peculiarities of form are so exactly matched that none can be regarded as of more than individual importance. The "relatively large extent and flatness of its smooth upper squamous portion" (l. c. p. 128) is completely within the range of variation in modern species of *Homo.* This feature, connected as it is with the upright position of the body, and the consequent shrinking of the area for attachment of the neck-muscles, is one of the family characters of the *Hominidæ.* In the *Pongidæ* a very small smooth area[1] is present in the young above the region of muscle-attachment, but in the adult this area is always encroached on[2] and often obliterated

[1] More noticeable in *Gorilla* and *Pan* than in *Pongo.*

[2] More rapidly and completely in *Gorilla* and *Pongo* than in *Pan.*

by the constantly increasing lambdoid crest. The fact that the squamous portion of the occipital bone is well developed in the fossil therefore indicates wide divergence from the known great apes. Another fancied resemblance to the *Pongidæ* is seen by Boule, who remarks (1915, p. 59) that to him the lower curved line appears to lie relatively nearer to the upper curved line than in recent *Homo,* its position thus more as in *H. neanderthalensis* and still more as in the chimpanzees. The distance between the two lines in the Piltdown skull is 15.5 mm. In two adult skulls of American Indians, one from Illinois (No. 243881) the other from North Dakota (No. 228876), which happened to be lying side by side in one of the exhibition cases it is respectively 14.5 mm. and 27 mm. Among adult chimpanzees I find extremes of 15.5 mm. (No. 174790) and 24.5 mm. (Nos. 84655 and 176227). When a character varies so much in both genera no conclusion can be based on the conditions found in any one skull. Even if a conclusion regarding the lines were justified it would have little meaning in view of the strictly human features of all other parts of the occipital bone.

Aside from the superior maxilla the parts of the skull most directly related to the mandible are: (a) the point of actual contact, (b) the region of origin of the masseter muscle, and (c) that of origin of the temporal muscle. Of these three the first and last are well preserved in the fossils. The glenoid region has been recognized as "typically human in every detail" (Dawson and Woodward, 1913, p. 128). Comparison with many human skulls shows that it presents the characteristically human features of narrow articulating surface and deep fossa in a much more than usual degree of development. Unfortunately the absence of the condyle makes it impossible to know whether the corresponding surface of the Piltdown jaw had the broad and slightly convex form seen in all three genera of living *Pongidæ;* but the part immediately below the fracture shows, in the region over the dental foramen, the highly developed strengthening ridge characteristic of the genus *Pan* (see pl. 1). A slight indication of the ridge is often present in *Homo;* but I have been unable to find a specimen even among those in a set particularly selected to illustrate the variations of human mandibles, in which the structure of this region agrees with living chimpanzees and the Piltdown jaw. The facts are that the Piltdown skull presents extreme human characteristics in the glenoid region calling for correspondingly extreme human conditions of narrow and strongly convex articular surface in the mandible which hinged on it. But this entire mandible, from sym-

physis to base of condyle, is like that of a chimpanzee. Hence in order to fit its articulating surface to that of the skull it would be necessary to imagine an abrupt change of plan in the few millimeters of condyle that have been lost.

Another incongruity is found when the area of origin of the temporal muscle on the skull is compared with that of its insertion on the mandible. Both regions have been carefully described and figured (Dawson and Woodward, 1913, pp. 128, 131, pl. 18, fig. 3, pl. 20, figs. 2a, 2c). The anterior border of the muscle appears to have extended upward on the frontal with somewhat unusual abruptness, an impression that may be heightened by the way in which the bone is broken. The posterior border was not carried very far back on the parietal. In general features the area of origin for the whole muscle is strictly human, and its extent is considerably less than in many of the human skulls with which I have compared it. In all three genera of *Pongidæ* this area is much greater in proportion to the size of the animal, pushing its way in adult individuals gradually over the braincase to median line, where the muscles of the two sides are often separated merely by a sagittal crest.[1] The area of insertion of the muscle on the Piltdown mandible has not only all the more important general characters peculiar to this region in *Pan;* it has also the individual features which in living members of that genus are connected with the greatest extension of the area of origin of the muscle on the skull. Young chimpanzees show a slight approximation to *Homo* in the form of the area on which the temporal muscle is inserted. The ridge which extends upward from the base of the coronoid process is broad and low, giving this whole region the smoothly convex appearance usually found in members of the family *Hominidæ*. With increasing age the ridge becomes narrower and the region behind it changes from flat to concave; finally the surface of the main ridge becomes marked by secondary ridgelets which give extreme strength of attachment to the muscle-fibers. This last stage of roughening on the mandible is associated in chimpanzees with the closest approach of the upper end of the muscle to the median line of the braincase and especially with the formation of a sagittal crest. It is well-marked in the Piltdown jaw. In order to associate this jaw with the braincase it would therefore be necessary to assume the existence of an animal related to both *Homo* and *Pan* but with a temporal muscle working on a different mechanical scheme from either; that is, moderate in size and strength at the

[1] Most frequently developed in *Gorilla*, least frequently in *Pan*.

region of origin on the skull and excessively heavy at the mandibular end. That such an animal may have lived cannot be denied; but nothing so contrary to the facts which are now known need be believed without the evidence of a jaw found in place.

Two other features of the human skull, both connected with the upright position of the body, and both represented by the Piltdown fragments, have an important bearing on the question of the association of the mandible with the braincase. One of these is the form of the basicranial region, the other is that of the nasals. That human skulls differ from those of other primates in the position of the foramen magnum and the occipital condyles appears to have been first clearly recognized by Daubenton, as long ago as 1764.[1] The subject has received attention from many subsequent authors.[2] While some individual variation in this respect is shown by recent man, and the conditions may prove to be less pronounced in the Pleistocene *Homo neanderthalensis* than in living members of the group,[3] the family *Hominidæ* is distinguished from all other mammals by the fact that the occipital region is so produced behind the condyles, while at the same time the anterior maxillary region (including front of lower jaw) is so retracted, that the points of support on the erect upper portion of the vertebral column stand essentially beneath the center of gravity of the skull, thus balancing the head in its characteristic poise. As a result of the maxillary retraction the nasal floor is shortened anteriorly and the nasal aperture is made to open directly forward instead of forward and upward. The nasal bones roofing this modified aperture are normally thrown into a prominence unknown in any monkey or great ape. Whether the maxillary retraction came about primarily as part of a general readjustment of the skull to its upright attitude or through other agencies, the fact remains that this character is not yet known among primates except as part of a set of changes, one result of which is to bring the point of cranial support to the position where it affords the most effective balance. In all primates other than the *Hominidæ* the condyles lie behind the center of gravity and the head is held in place on the oblique or horizontal anterior portion of the

[1] Mém. Acad. Roy. Sci., Paris (1764), pp. 568-577. 1767.

[2] See, for instance, Huxley, Man's Place in Nature, p. 76, 1863; Owen Comp. Anat. and Physiol. Vert., vol. 2, p. 554, 1866; Broca, Rev. d'Anthrop., Paris, vol. 2, pp. 193-234, 1873 (reprint in Mém. d'Anthrop., vol. 4, pp. 595-641, 1883); Papillault, Bull. Soc. Anthrop., Paris, ser. 4, vol. 9, pp. 336-385.

[3] See Boule, Ann. de Paléont., vol. 6, pp. 156-159, 1911 (l'Homme fossile de la Chapelle-aux-Saints, pp. 48-51).

vertebral column by strong muscles;[1] the anterior maxillary region is not retracted, and the nasal bones are flatly sunk into the interorbital region and the upper border of the nasal orifice. In the *Hominidæ* the peculiar position of the condyles is accompanied by special modifications in the floor of the braincase. The area between the foramen magnum and the choanæ is bowed upward, the mastoid process is carried downward and forward until it almost encroaches on the region lying below glenoid notch, and the tympanic plate and entire petro-mastoid are distorted from their primitive form. The temporal bone of *"Eoanthropus"* (Dawson and Woodward, 1913, pl. 19, fig. 2) shows by its exact resemblance to the same bone in *Homo* that this fundamental part of the skull was completely adjusted to the task of supporting a human brain in the upright position. Belief that a primate like the one to which this temporal bone belonged, and living as recently as the late pliocene or early pleistocene, lacked that corresponding balance-adjustment in the maxillary region which is present in all members of the *Hominidæ* actually known, cannot reasonably exist without the evidence of an entire specimen; yet such absence of mechanical unity between the two parts of the skull must be assumed in order to provide the specimen with a long, narrow upper arch to fit the lower jaw[2] (compare pls. 3 and 4). Similarly, in the absence of a specimen showing human nasal bones coexisting with the protruding anterior maxillary region of the great apes, there is every reason to suppose that the Piltdown jaw was not closely associated with this pair of typical human nasals (Dawson and Woodward, 1914, pl. 15, fig. 1) until the deposition of the remains near each other in the old river-bottom. It is not improbable that ancient

[1] A peculiar instance of approach to a balanced condition of the head is furnished by the South American monkeys of the genus *Saimiri*. Here the back part of braincase protrudes so far that the condyles are made to be nearer the middle of the skull than in any other monkey that I have examined. There is no indication of a general readjustment of the skull, the base of braincase together with the facial region remaining as in related genera.

[2] As the cranial floor between the temporal bone and the median line is not represented by the fragments it is perhaps not safe to assume that the distance from one glenoid to the other was as great as in recent *Homo*. Every feature of the specimen makes it appear probable, however, that such was actually the case. If this human widening existed, the articular surfaces of the corresponding jaw, to accord with the conditions present in all other known primates, should have been wide apart, the jaw should have been strongly arched, and the lower toothrow should have begun to bend inward behind the premolars. Neither the teeth nor the horizontal portion of the Piltdown mandible present any such characters.

fossil forms will be found in which the characters of face, braincase, jaws and teeth are so generalized as to represent a structure that could have given rise to the distinguishing features of both *Hominidæ* and *Pongidæ*. But nothing could be more contrary to the conditions present in all living and fossil *Anthropoidea* now known than the simultaneous occurrence in a pleistocene or recent genus of fully developed fundamental characters elsewhere diagnostic of the two groups.

Summary

The Piltdown remains include parts of a braincase showing fundamental characters not hitherto known except in members of the genus *Homo,* and a mandible, two lower molars, and an upper canine showing equally diagnostic features hitherto unknown except in members of the genus *Pan.* On the evidence furnished by these characters the fossils must be supposed to represent: either a single individual belonging to an otherwise unknown extinct genus (*Eoanthropus*), or two individuals belonging to two now-existing families (*Hominidæ* and *Pongidæ*). The fossils are so fragmentary that their zoological meaning will probably remain a subject of controversy. Yet the weight of the difficulties on the two sides is unequal. In order to believe that all the fragments came from a single individual it is necessary to assume the existence of a primate differing from all other known members of the order by combining a braincase and nasal bones possessing the exact characters of a genus belonging to one family, with a mandible, two lower molars, and an upper canine possessing the exact characters of a genus belonging to another. Thus must be associated in a single skull: (a) one type of jaw with another type of glenoid region, (b) one type of temporal muscle-origin with another type of temporal muscle-insertion, (c) a high degree of basicranial adjustment to the upright position with absence of that corresponding modification in the lower jaw called for by all that is now actually known of the structure of the braincase and mandible in primates, and (d) a protruding lower jaw with a form of nasal bone not elsewhere known except in connection with a retracted upper dental arch. In each instance the opposed characters are sharply defined and easily recognizable in the fossils; while in no single feature is there any trace of the blending of the two types. On the other hand the assumption that the skull and jaw belonged respectively to a man and a chimpanzee carries with it only two difficulties: (a) that of the deposition within a few feet of each other of the remains of two animals whose bones are rarely found in gravel

pits, and (b) that of the supposed absence of chimpanzees from the European pleistocene faunas. Concerning the first nothing can be said, except that those local conditions which caused the deposition of one specimen near a given spot might be expected to act in about the same way with another. The second is at least partly met by the fact that a tooth described and figured as not certainly distinguishable from the first lower molar of a chimpanzee has been found in the pleistocene of Germany. Until the discovery of further material it seems proper to treat the case as a purely zoological problem by referring each set of fragments to the genus which its characters demand.

The British Pleistocene Chimpanzee

Accepting the conclusions (a) that each set of the Piltdown fragments shall be treated according to the existing characters, and (b) that the characters of the lower jaw are those of a member of the genus *Pan,* it becomes necessary to distinguish the British pleistocene chimpanzee from the living African species. No special fragment was designated by Dr. Woodward as the type specimen of *Eoanthropus dawsoni.* As the species was referred to the family *Hominidæ* I now restrict the name to the human elements of the composite, selecting as type the temporal bone (Quart. Journ. Geol. Soc. London, vol. 69, pl. 19, fig. 2). For the chimpanzee represented by the mandible with its first and second molar teeth I propose the name:

PAN VETUS, sp. nov.

(Pl. 1, fig. 2, pl. 2, fig. 2)

Diagnosis.—General characters of mandible and of first and second lower molars as in living species of *Pan* from French Congo and southern Kameroon, but horizontal ramus more robust and teeth larger.

Measurements.—In the table (page 20) the measurements of the type (from cast) are compared with those of seven mandibles of *Pan* from French Congo and Kameroon, among which are represented the maximum and minimum dimensions for the entire National Museum series of adults. Only one of these individuals contrasts noticeably with the type in the worn condition of the molar crowns. For convenience of further comparisons I have added the measurements of *Homo heidelbergensis* (from cast) and of three specimens of modern *Homo,* one extremely large, another medium in size and the third rather small.

TABLE OF MEASUREMENTS.

Locality.	Number.	Sex.	Length of mandible at alveolar level from posterior border to symphysion.	Distance from posterior border of mandible to front of m_1 (alveolus).	Diameter of ascending ramus at alveolar level.	Depth of ascending ramus from lowest point of sigmoid notch.	Depth of horizontal portion at middle of m_3.	Depth of horizontal portion at middle of m_1.	Width of horizontal portion at middle of m_3.	Greatest width of horizontal portion below middle of m_1.	Combined alveolar length of three molars.	Crown of first molar.	Crown of second molar.	Worn condition of teeth as compared with those of *Pan vetus*.
***Pan* sp. (recent).**														
French Congo	174707	♀	109.4	68.0	40.6	....	21.2	23.0	14.8	10.6	31.4	10.2×9.6	11.0×9.8	Slightly less.
French Congo	174701	♀	113.6	72.0	44.0	49.0	29.4	27.6	16.6	12.9	32.0	10.8×10.0	11.2×9.8	Distinctly less.
S. Kameroon	176229	♀	117.4	77.8	51.2	49.6	27.6	30.2	17.0	13.8	32.0	10.0×9.0	11.0×10.0	Slightly more.
French Congo	174699	♀	120.4	78.4	47.6	47.4	27.2	27.7	16.8	15.2	34.6	.....	.....	About the same.
French Congo	174710	♀	123.3	80.4	50.6	62.0	28.0	30.6	16.4	13.0	32.6	10.0×9.6	10.8×10.0	Noticeably more.
S. Kameroon	176235	♂	115.7	80.0	51.6	52.4	24.2	26.4	17.2	14.6	33.8	10.6×10.6	11.0×11.6	Slightly less.
French Congo	174704	♂	125.8	81.0	52.0	61.2	27.2	28.2	17.5	14.8	34.0	11.0×9.4	11.0×10.6	Distinctly less.
Minimum.....	.....	...	109.4	68.0	40.6	47.4	21.2	23.0	14.8	10.6	31.4	10.0×9.0	10.8×9.8	
Maximum	.....	...	125.8	81.0	52.0	62.0	29.4	30.6	17.5	15.2	34.6	11.0×10.6	11.0×11.6	
***Pan vetus* (pleistocene).**														
England.....	.....	♀?	*120±	76.8	47.0	61.0	29.8	31.0	21.2	14.8	39.0	12.5×10.5†	13.0×11.0†	
***Homo heidelbergensis* (pleistocene).**														
Germany	.....	...	120.5	92.2	58.8	61.4	30.7	34.6	23.0	19.0	35.8	11.8×11.4	12.6×12.2	
***Homo* sp. (recent).**														
			101.8	75.6	46.8	53.6	33.4	37.5	20.8	20.2	35.2	12.6×11.6	12.4×11.0	
			95.0	71.4	45.3	62.0	35.4	42.3	20.4	18.8	36.4	12.2×11.8	12.6×11.4	
			90.2	66.2	36.2	42.2	23.4	27.5	15.2	11.5	28.6	10.2×9.8	9.6×9.0	

*Estimated. Error probably less than 5 mm.

† Dr. Woodward's measurements are respectively: 11.5×9.5 and 12.0×10.0 mm. Apparently he took into consideration the flattened surface only.

Remarks.—Within the limits of the generic characters recent chimpanzees, like other great apes, show many variations the nature of which is imperfectly understood. Numerous species have been described[1] but their cranial peculiarities, if such exist, are not yet known. Among the skulls in the National Museum series I have been unable to find satisfactory characters by which to distinguish local forms.

Comparing the Piltdown mandible with those from Kameroon and French Congo I have found no constant features other than those already mentioned. That part of mandible in front of m_1 is, for instance, shorter than in the two African jaws figured on plate 1; but No. 174710 (pl. 5, fig. 2) from French Congo has this region fully as short and nearly as deep as the type. In *Pan vetus* the thickened area which extends downward on outer side of mandible in continuation of the base of the coronoid process is more prominent than in most African specimens. It contributes to the robustness of the jaw in that region, and stands out noticeably beyond the level of the lower edge when the mandible is viewed at a certain angle from above. In African specimens this thickening is usually not sufficient to project noticeably beyond the level of the angular margin, but in No. 176235 from southern Kameroon it does so almost as much as in *Pan vetus*. The angle of the jaw is more evenly rounded off in *Pan vetus* than in most African chimpanzees that I have seen. These usually show a slight concavity below the angular region and another, often the more pronounced of the two, above it. In No. 174710 (pl. 5, fig. 2) from French Congo a very slight wearing away of the edge of the bone such as appears to have taken place in the Piltdown jaw would exactly produce the outline of the type. The teeth appear to be more diagnostic than the jaw, as I have been unable to find any African specimen in which they equal those of *Pan vetus* in size.

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[1] See Elliot, Rev. Primates, vol. 3, pp. 229-254, June, 1913, and Matschie, Sitzungsber. Gesellsch. naturforsch. Freunde, Berlin, 1914, pp. 327-335, July, 1914.

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ANTHONY, R. Les restes humains fossiles de Piltdown (Sussex). Revue Anthropologique, vol. 23, pp. 293-306. September, 1913.

Accepts the association of the skull with jaw: "Ce qui pourrait le rendre vraisemblable c'est que, chez les jeunes Anthropoïdes nous voyons précisément associée à une boite crânienne sensiblement sphérique une mâchoire à menton fuyant," p. 304. Regards the formation of a new genus as not justified: "En raison de sa capacité cranienne tôute humaine il me semble cependant contre-indiqué de le séparer du genre *Homo*. Le nom spécifique d'*Homo dawsoni* me semble devoir etre préfére à celui d' *Eoanthropus dawsoni* . . . ." (p. 305).

BOULE, MARCELLIN. L'Homme fossile de la Chapelle-aux-Saints. Annales de Paléontologie, vol. 6, pp. 111-172, 1911, vol. 7, pp. 21-56, 85-192, 1912, vol. 8, pp. 1-70. 1913.

Eoanthropus frequently mentioned, pp. 245-265, but at this time known to the author from descriptions only. (See next title.)

BOULE, MARCELLIN. La Paléontologie humaine en Angleterre. L'Anthropologie, vol. 26, pp. 1-67, figs. 1-21. April, 1915.

Eoanthropus, pp. 39-67. Accepts association of skull with jaw, though recognizing that jaw is exactly that of a chimpanzee, and that it would have been described as *Troglodytes dawsoni* if found alone (p. 60). Admits that the presence of a pliocene anthropoid ape in western Europe would be nothing extraordinary (p. 62). Regards the creation of a new genus as unnecessary. Criticizes Waterston's view that jaw did not belong with skull: "Cet argument, d'ordre purement anatomique, n'est donc pas sans valeur. Mais il a le tort d'etre imprégné d'un vieux parfum cuviérin et de reposer trop exclusivement sur les données morphologiques tirées de l'Homme actuel. Or, les paléontologistes savent combien la nature est fertile en combinaisons imprévues; elle a pu associer d'autant plus facilement un condyle et une fosse glénoïde d'Homme à une mâchoire de Singe que, mécaniquement et physiologiquement, cette association ne paraît pas absurde. Il semble que, dans l'évolution d'une tête osseuse, quand la face diminue, la mandibule diminue plus lentement, ne suivant en quelque sorte que de loin le mouvement de retrait" (p. 62).

DAWKINS, BOYD. [Discussion of the Piltdown skull.] Abstr. Proc. Geol. Soc. London, session 1912-13, pp. 23-24. December 28, 1912. (See also Quart. Journ. Geol. Soc. London, vol. 69, pp. 148-149. March, 1913, issued April 25, 1913.)

Accepts association of skull and jaw. Concludes that *Eoanthropus* is "a missing link between man and the higher apes, appearing at that stage of the evolution of the higher mammalia in which it may be looked for—in the pleistocene age. The modern type of man had no place in this age."

DAWSON, CHARLES, and WOODWARD, ARTHUR SMITH. On the discovery of a palaeolithic human skull and mandible in a flint-bearing gravel overlying the Wealden (Hastings Beds) at Piltdown, Fletching (Sussex). Abstr. Proc. Geol. Soc. London, session 1912-13, pp. 20-22. December 28, 1912.

Abstract of history and characters. Name not printed. ". . . . it may be regarded as representing a hitherto unknown genus and species, for which a new name is proposed."

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DAWSON, CHARLES, and WOODWARD, ARTHUR SMITH. Supplementary note on the discovery of a palaeolithic human skull and mandible at Piltdown (Sussex). Abstr. Proc. Geol. Soc. London, session 1913-1914, pp. 28-29. December 31, 1913.

"In shape, the canine resembles the milk canine of man and that of the apes more closely than it agrees with the permanent canine of any known ape. In accordance with a well-known palaeontological law, it therefore approaches the canine of the hypothetical Tertiary Anthropoids more nearly than any corresponding tooth hitherto found."

DAWSON, CHARLES, and WOODWARD, ARTHUR SMITH. Supplementary note on the discovery of a palaeolithic human skull and mandible at Piltdown (Sussex). Quart. Journ. Geol. Soc. London, vol. 70, pp. 82-93, pls. 14-15, figs. 1-3. April 25, 1914.

"It results, therefore, from these comparisons that, among known Upper Tertiary and Recent Anthropoids, the permanent lower canine of *Eoanthropus* agrees more closely in shape with the milk-canine both of man and of the apes than with the corresponding permanent tooth in either of these groups. It is also obvious that the resemblance is greater between *Eoanthropus* and *Homo* than between the former and any known genus of apes. In other words, the permanent tooth of the extinct *Eoanthropus* is almost identical in shape with the temporary milk-tooth of the existing *Homo*. Hence it forms another illustration of the well-known law in mammalian palaeontology, that the permanent teeth of an ancestral race agree more closely in pattern with the milk teeth than with the permanent teeth of its modified descendants" (p. 91).

DUCKWORTH, DR. [Discussion of the Piltdown skull]. Abstr. Proc. Geol. Soc. London, session 1912-1913, p. 24. December 28, 1912. (See also Quart. Journ. Geol. Soc. London, vol. 69, p. 149. March, 1913. Issued April 25, 1913.)

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"The hominid *Eoanthropus dawsoni* (Piltdown) is undoubtedly of pre-chalky boulder-clay age" (p. 393).

KEITH, A. [Discussion of the Piltdown skull.] Abstr. Proc. Geol. Soc. London, session 1912-13, p. 23. December 28, 1912. (See also Quart. Journ. Geol. Soc. London, vol. 69, p. 148. March, 1913. Issued April 25, 1913.)

Accepts association of skull with jaw but considers that reconstruction of jaw is made to be too much like chimpanzee.

KEITH, A. Ape-man or Modern Man? The two Piltdown skull reconstructions. Illustrated London News, vol. 143, p. 245, figs. 1-6. August 16, 1913.

Jaw reconstructed to hold a human dentition.

KEITH, A. Ape-man or Modern Man? The two Piltdown skull reconstructions. The case for Professor Arthur Keith's reconstruction. Illustrated London News, vol. 143, p. 282. August 23, 1913. 4 figures.

Reconstruction of jaw to resemble as nearly as possible that of *Homo*.

KEITH, A. The Piltdown Skull and Brain Cast. Nature, vol. 92, pp. 197-199, figs. 1-3. October 16, 1913.

KEITH, ARTHUR. The Piltdown Skull and Brain Cast. Nature, vol. 92, p. 292. November 6, 1913.

KEITH, ARTHUR. The Piltdown Skull and Brain Cast. Nature, vol. 92, pp. 345-346. November 20, 1913.

KEITH, A. [Discussion of new reconstruction of skull of *Eoanthropus*.] Abstr. Proc. Geol. Soc. London, session 1913-14, p. 30. December 31, 1913. (See also Quart. Journ. Geol. Soc. London, vol. 70, p. 98, April 25, 1914.)

Admits difficulties in associating jaw, skull and canine as parts of one individual, but regards all as representing one species: "Two other difficulties he had encountered were (1) the presence of a pointed projecting canine in the jaw and an articular eminence at the glenoid fossa of the skull; and (2) a much-worn canine tooth in a jaw in which the third molar tooth—according to the published X-ray photograph of the Piltdown mandible—was not completely erupted. (See Underwood, December 31, 1913.) He agreed that all three parts—skull, jaw, and canine tooth—must be assigned to *Eoanthropus*, but he was not convinced that they could all belong to the same individual."

KEITH, A. Problems relating to the teeth of the earlier forms of prehistoric man. Proc. Roy. Soc. Medicine, vol. 6, Odont. sect., pp. 103-119, figs. 1-10. 1913.

Piltdown mandible, pp. 116-119.

KEITH, ARTHUR. The Significance of the Discovery at Piltdown. Bedrock, vol. 2, pp. 435-453, figs. 1-3. January, 1914.

"There is one way out of this difficulty—that suggested by Sir E. Ray Lankester and urged by Professor Waterston—namely, that the mandible and skull are parts of different kinds of beings; the mandible that of some unknown anthropoid, and the skull that of a primitive form of man. When we seek to get out of our difficulty in this way we raise others. The molar teeth in the Piltdown mandible are essentially human in appearance; the texture of the mandible is similar to that of the skull. The markings for the temporal muscle, which acts on the jaw, are different to any ever seen in a human skull and indicate that the mandible should be of a peculiar character—such as has been found."

KEITH, ARTHUR. The reconstruction of fossil human skulls. Journ. Royal Anthrop. Isnt. Gt. Brit. and Ireland, vol. 44, pp. 12-31, figs. 1-16. January-June, 1914.

Describes process of reconstructing the Piltdown skull.

KEITH, ARTHUR. The Antiquity of Man. London and Philadelphia, 1915, (preface dated July), pp. I-XX, 1-519, 189 figures and diagrams.

Piltdown skull, pp. 293-511; the most elaborate discussion yet published. Account of mandible with special reference to simian features, pp. 430-452 (drawings reproduced in figs. 165 and 167 should be compared with photographs in present article). Account of teeth, pp. 453-457. Conclusions: "Thus in our scrutiny and reconstruction of the Piltdown mandible, although we have come across many details of structure which seem to suggest that it formed part of an anthropoid rather than a human being, we have met with no feature which clearly debars it from being placed with the skull . . . . our difficulties are infinitely greater if we try to allocate the skull to a human being and the mandible to an unknown kind of anthropoid (p. 453) . . . . Thus in the manner in which it has become worn by use the Piltdown canine differs from all known human and anthropoid [mandibular] teeth (p.

459). The molar teeth leave us in no doubt; they are human. If the question is asked: What are the characters of these teeth which are so essentially human? it must be confessed that a direct and explicit answer is not easily returned . . . . However we may waver about the Piltdown mandible, the clear direct evidence of the molar teeth comes ever to our aid" (pp. 469-470). Places *Eoanthropus* on a line distinct from those leading to *Homo heidelbergensis* and *H. neanderthalensis* on the one hand and to modern man on the other (p. 501). (See Pilgrim and Sutcliffe.) "That we should discover such a race [human, with canine teeth pointed, projecting, and shaped as in anthropoid apes], has been an article of faith in the anthropologist's creed ever since Darwin's time" (p. 459). Received too late for notice in body of text.

LANKESTER, RAY. [Discussion of the Piltdown skull.] Abstr. Proc. Geol. Soc. London, session 1912-13, pp. 22-23. December 28, 1912. (See also Quart. Journ. Geol. Soc. London, vol. 69, pp. 147-148. March, 1913. Issued April 25, 1913.)

"He did not consider it certain that the lower jaw and the skull belonged to the same individual."

MACCURDY, G. G. Ancestor Hunting: the Significance of the Piltdown Skull. Amer. Anthrop. n. s. vol. 15, pp. 248-256. April-June, 1913.

MOIR, J. REID. The Piltdown Skull. The Times, London, December 25, 1912, p. 8.

"In my opinion, then, Mr. Dawson is to be congratulated on having made the immensely important discovery of the remains of one of the beings who made the eolithic flint implements." (See Sutcliffe.)

MUNRO, ROBERT. Prehistoric Britain (Home University of Modern Knowledge), pp. I-VI, 1-256, figs. 1-24. 1913.

Eoanthropus, pp. 25, 52-55, 70-74, figs. 8-9. Accepts association of skull with jaw.

NEHRING, A. Ueber einen menschlichen Molar aus dem Diluvium von Taubach bei Weimar. Zeitschr. für Ethnologie, vol. 27, pp. 573-577, figs. 1-4. October, 1895.

The author regards this tooth as human, but is unable to compare it with anything except the first lower molar of a chimpanzee. According to the figures it almost exactly resembles the corresponding tooth of *Pan vetus.* Size not so great: 11.7 x 9.9 mm. In the actual specimen the similarity to m_1 of *Pan* is said to be still greater than in the drawing.

PILGRIM, GUY E. New Siwalik primates and their bearing on the evolution of man and the Anthropoidea. Rec. Geol. Surv. India, vol. 45, pp. 1-74, pls. 1-4, figs. 1-2.

Accepts association of skull with jaw and places *Eoanthropus* on line leading to *Homo neanderthalensis.* (See Keith, 1915, and Sutcliffe.)

PUCCIONI, NELLO. Appunti intorno al frammento mandibolare fossile di Piltdown (Sussex). Archivio per l'Antropologia e la Etnologia, vol. 43, pp. 167-175. 1913.

Jaw and skull not from one individual. Jaw more like Neanderthal man than like chimpanzee. "Mi sembra pertanto indubitabile che la mandibola in questione appartenga ad un tipo rozzo, a mio parere più simile al tipo di Neanderthal che non al *Troglodites* e mi sembra altresì che non si possa considerare probabile che i caratteri grossolani di questa mandibola si accompagnassero ai caratteri relativamente fini (assenza dell arcate sopraorbitarie, fronte alta e dritta ecc.) dei frammenti cranici che le furono rinvenuti accanto: ond'é, che concordemente a quanto pensano due eminenti scienziati inglesi (il Lankester e il Waterston), io sono di opinione che la mandibola ed il cranio abbiano probabilmente appartenuto a due individui distinti" (p. 175).

Puccioni, Nello. Morphologie du maxillaire inférieur. L'Anthropologie, vol. 25, pp. 291-321, figs. 1-3. 1914.

Reaffirms view that Piltdown mandible is less simian than Smith Woodward makes it appear (p. 315).

Pycraft, W. P. The most ancient inhabitant of England: the newly-found Sussex Man. Illustrated London News, vol. 141, p. 958. December 28, 1912.

Pycraft, W. P. Ape-Man or Modern Man? The two Piltdown skull reconstructions. The case for Dr. A. Smith Woodward's reconstruction. Illustrated London News, vol. 143, p. 282. August 23, 1913. Four figures.

"But no one competent to express an opinion would accept this interpretation [that skull is man and jaw ape]."

Robinson, Louis. The Story of the Chin. Knowledge n. s., vol. 10, pp. 410-420. November, 1913. (Reprinted in Smithsonian Report for 1914, pp. 599-609, pls. 1-12, 1915.)

Piltdown jaw (symphyseal region) figured (pl. 7) but not mentioned in the text.

Schwalbe, G. Kritische Besprechung von Boule's Werk: "L'Homme fossile de la Chapelle-aux-Saints." Zeitschr. für Morphologie und Anthropologie, vol. 16, pp. 227-610. January 31, 1914.

Piltdown skull and jaw, pp. 603-4. Not willing to accept the suggestion that skull and jaw did not belong to one individual, but considers the facts too uncertain to form basis of positive opinion.

Shattock, S. G. Morbid thickening of the calvaria; and the reconstruction of bone once abnormal; a pathological basis for the study of the thickening observed in certain pleistocene crania. Seventeenth International Congress of Medicine, London, 1913, sect. 3, pt. 2, pp. 3-46, pls. 1-4, text figs. 1-3. 1914.

Piltdown skull, pp. 42-46. "But to conclude. Without making any dogmatic statement, certain details of the Piltdown calvaria suggest the possibility of a pathological process having underlain the thickened condition" (p. 46). Accepts association of skull with jaw, and regards the third lower molar as unerupted (p. 43). See Underwood, December 31, 1913.

Smith, G. Elliot. Appendix [to paper by Dawson and Woodward]. Abstr. Proc. Geol. Soc. London, session 1912-13, p. 22. December 28, 1912.

Abstract of paper mentioned under next title. The last paragraph of abstract does not occur in full account. It is: "There are no grounds whatever for supposing that this simian jaw and human braincast did not belong to one and the same individual, who was probably a right-handed female."

Smith, Grafton Elliot. Preliminary report on the cranial cast [of the Piltdown skull]. Quart. Journ. Geol. Soc. London, vol. 69, pp. 145-147. March, 1913. Issued April 25, 1913.

Smith, G. Elliot. The Piltdown Skull. Nature, vol. 92, p. 131. October 2, 1913.

Accepts association of skull with jaw and adds: "The small and archaic brain and thick skull are undoubtedly human in character, but the mandible, in spite of the human molars it bears, is more simian than human. So far from being an impossible combination of characters, this association of brain and simian features is precisely what I anticipated in my address to the British Association at Dundee (Nature, September 26, 1912, p. 125), some months before I knew of the existence of the Piltdown skull, when I argued that in the evolution of man the development of the brain must have led the way. The

growth in intelligence and in the powers of discrimination no doubt led to a definite cultivation of the aesthetic sense, which, operating through sexual selection, brought about a gradual refinement of the features."

SMITH, G. ELLIOT. The Piltdown Skull and Brain Cast. Nature, vol. 92, pp. 267-268. October 30, 1913.

SMITH, G. ELLIOT. The Piltdown Skull and Brain Cast. Nature, vol. 92, pp. 318-319. November 13, 1913.

SMITH, G. ELLIOT. The controversies concerning the interpretation and meaning of the remains of the dawn-man found near Piltdown. Nature, vol. 92, pp. 468-469. December 18, 1913.

"There is definite internal evidence that the jaw is not really an ape's; the teeth it bears are human . . . ."

SMITH, G. ELLIOT. On the exact determination of the median plane of the Piltdown skull. Abstr. Proc. Geol. Soc. London, session 1913-14, p. 29, December 31, 1913. (See also Quart. Journ. Geol. Soc. London, vol. 70, pp. 93-97, figs. 4-6, April 25, 1914.)

SMITH, G. ELLIOT. The controversies concerning the interpretation and meaning of the remains of the dawn-man found near Piltdown. Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 58, pp. VII-IX. March 31, 1914.

"That the jaw and cranial fragments . . . . belonged to the same creature there had never been any doubt on the part of those who have seriously studied the matter" (p. VIII). The author believes that: "When man was first evolved the pace of evolution must have been phenomenally rapid." He alludes to "the turmoil incident to the inauguration of the Pleistocene Period" (p. IX).

SMITH, G. ELLIOT. The Significance of the Discovery at Piltdown. Bedrock, vol. 3, pp. 1-17. April, 1914.

A detailed criticism of Professor Keith's views.

SOLLAS, W. J. Ancient Hunters and their Modern Representatives. Ed. 2, London, 1915, pp. I-XIV, 1-591, 314 figs.

Piltdown man, pp. 49-56. "Some have regarded such a being as an improbable monster and have suggested that the jaw may not have belonged to the skull, but to a true ape. The chances against this are, however, so overwhelming that the conjecture may be dismissed as unworthy of serious consideration. Nor on reflection need the combination of characters presented by *Eoanthropus* occasion surprise. It had, indeed, been long previously anticipated as an almost necessary stage in the course of human development" (p. 54).

SUTCLIFFE, W. H. A criticism of some modern tendencies in prehistoric anthropology. Mem. & Proc. Manchester Lit. and Philos. Soc., vol. 57, no. 7, pp. 1-25, pls. 1-2. June 24, 1914.

Skull and jaw "undoubtedly belonging to the same individual." *Eoanthropus* placed on line leading to *Homo sapiens*, pl. 1. (See Keith, 1915, and Pilgrim.) Eoliths produced by natural agencies. (See Moir.)

THACKER, A. G. The Significance of the Piltdown Discovery. Science Progress, vol. 8, pp. 275-290. October, 1913.

Accepts association of skull with jaw.

TYRELL, G. W. The Sussex Skull. Knowledge, vol. 36, p. 61, February, 1913.

Account of paper by Dawson and Woodward. Name *Eoanthropus* not printed.

UNDERWOOD, ARTHUR S. The Piltdown Skull. British Journal of Dental Science, vol. 56, pp. 650-652, 3 plates (not numbered). October 1, 1913.

Accepts association of skull with jaw, but shows by means of radiographs the exact similarity of the jaw to that of a chimpanzee. Does not especially discuss the characters of the molars.

UNDERWOOD, A. S. [Discussion of "Supplementary Note" on Piltdown skull.] Abstr. Proc. Geol. Soc. London, session 1913-14, pp. 30-31. December 31, 1913. (See also Quart. Journ. Geol. Soc. London, vol. 70, p. 99. April 25, 1914.)

"The sockets of the third molar were not those of an erupting tooth, the roots had been quite completed, and the tooth was in its final position at death." (See Keith, December 31, 1913.)

VRAM, U. G. Le reconstruzioni dell' Eoanthropus Dawsoni, Woodward. Boll. Soc. Zool. Ital., Roma, ser. 3, vol. 2, pp. 195-198. 1913.

Accepts association of jaw with skull, but considers that a new species should not have been based on such incomplete material.

WALKHOFF, DR. Entstehung und Verlauf der phylogenetischen Umformung der menschlichen Kiefer seit dem Tertiär und ihre Bedeutung für die Pathologie der Zähne. Deutsche Monatsschr. für Zahnheilkunde, vol. 31, pp. 947-979, figs. 1-9. December, 1913.

Piltdown jaw, pp. 971-979. Accepts association of skull and jaw. Regards the jaw as a confirmation of his views on the origin of the chin. "Das Kieferbruchstück von Piltdown wird damit zu einem neuen, sehr wichtigen Beweise für meine Theorie der Kinnbildung, nach welcher eine Reduktion des gesammten Kiefers, insbesondere aber des Kieferkörpers in dorsaler Richtung stattfand mit Ausnahme der vorderen Basalpartie, welche unter dem Einfluss der Muskeln steht, die bei der artikulierten Sprache tätig sind" (p. 974).

WATERSTON, PROF. [Discussion of the Piltdown skull.] Abstr. Proc. Geol. Soc. London, session 1912-13, p. 25. December 28, 1912. (See also Quart. Journ. Geol. Soc. London, vol. 69, p. 150. March, 1913. Issued April 25, 1913.)

Very difficult to believe that the two specimens could have come from the same individual.

WATERSTON, DAVID. The Piltdown Mandible. Nature, vol. 92, p. 319, figs. 1-3. November 13, 1913.

Compares with chimpanzee and concludes that " . . . . it seems to me to be as inconsequent to refer the mandible and the cranium to the same individual as it would be to articulate a chimpanzee foot with the bones of an essentially human thigh and leg."

WOODWARD, A. SMITH. The Piltdown Skull. Brit. Med. Journ., vol. 2 for 1913, p. 762. September 20, 1913.

Abstract of lecture before the British Association at Birmingham on September 16. Announcement of discovery of canine tooth (see also next title). "As to the question whether the ape-like mandible belonged to the skull, it could only be said that its molar teeth were typically human, its muscle markings such as might be expected, and that it was found in the gravel near the skull." "The Piltdown man might . . . . well have been the direct ancestor of modern man, connecting him with the undiscovered tertiary apes, whose rounded skulls must have resembled those of the immature young of existing apes."

WOODWARD, A. SMITH. The Piltdown Skull. Nature, vol. 92, pp. 110-111. September 25, 1913.

Abstract of lecture before the British Association at Birmingham on September 16. Announcement of discovery of canine tooth. "This tooth corresponds exactly in shape with the lower canine of an ape, and its worn face shows that it worked upon the upper canine in the true ape fashion."

WOODWARD, A. SMITH. Note on the Piltdown Man (*Eoanthropus dawsoni*). Geol. Mag. n. s., dec. 5, vol. 10, pp. 433-434, pl. 15. October, 1913.

WOODWARD, A SMITH. A Guide to the Fossil Remains of Man in the British Museum, pp. 1-33, pls. 1-4, figs. 1-12. 1915.

Contains photographs of the Piltdown remains (pls. 1-4). These should be compared with the wash drawings in Dawson and Woodward, April 25, 1913, particularly as regards the teeth.

EXPLANATION OF PLATES

PLATE 1

All figures about ¾ natural size. Casts.

FIG. 1. *Pan* sp. Africa: no exact locality. No. 84655, U. S. National Museum.

FIG. 2. *Pan vetus*, England: Piltdown.

FIG. 3. *Pan* sp. Africa: French Congo. No. 174700, U. S. National Museum.

The casts of the African specimens have been mutilated as nearly as possible in the same manner as the fossil.

PLATE 2

All figures about ¾ natural size. Casts, except nos. 1″, 2″ and 4.

FIG. 1. *Pan* sp. Africa: no exact locality. No. 84655, U. S. National Museum.

FIG. 2. *Pan vetus*, England: Piltdown.

FIG. 3. *Pan* sp. Africa: French Congo. No. 174700, U. S. National Museum.

FIG. 4. *Pan* sp. Africa: southern Kameroon. No. 176226, U. S. National Museum.

Fig. 2″ is copied from the photograph published by Dr. Woodward in the Guide to Fossil Remains of Man in the British Museum, pl. 4. Note that enamel on lingual side of metaconid has flaked off from m_1 in fig. 4.

PLATE 3

Skull greatly reduced, mandible about ¾ natural size.

Homo sp. Skull, North American Indian, No. 262540, U. S. National Museum; mandible, Mongolian, No. 278783, U. S. National Museum.

To show the association of cranial and mandibular characters normal in the *Hominidæ*.

PLATE 4

Skull greatly reduced, mandible about ¾ natural size.

Pan sp. African: southern Kameroon. No. 176226, U. S. National Museum.

To show the association of cranial and mandibular characters normal in the *Pongidae*.

PLATE 5

All figures about ⅔ natural size. Nos. 1 and 3 from casts.

Mandible of four adult individuals of recent *Pan* to show individual variation. Note particularly the symphysis, the sigmoid notch and the angular region.

FIG. 1. *Pan* sp. Africa: no exact locality. No. 84655, U. S. National Museum.

FIG. 2. *Pan* sp. Africa: French Congo. No. 174710, U. S. National Museum.

FIG. 3. *Pan* sp. Africa: French Congo. No. 174700, U. S. National Museum.

FIG. 4. *Pan* sp. Africa: southern Kameroon. No. 176244, U. S. National Museum. (Coronoid process restored.)

1

2

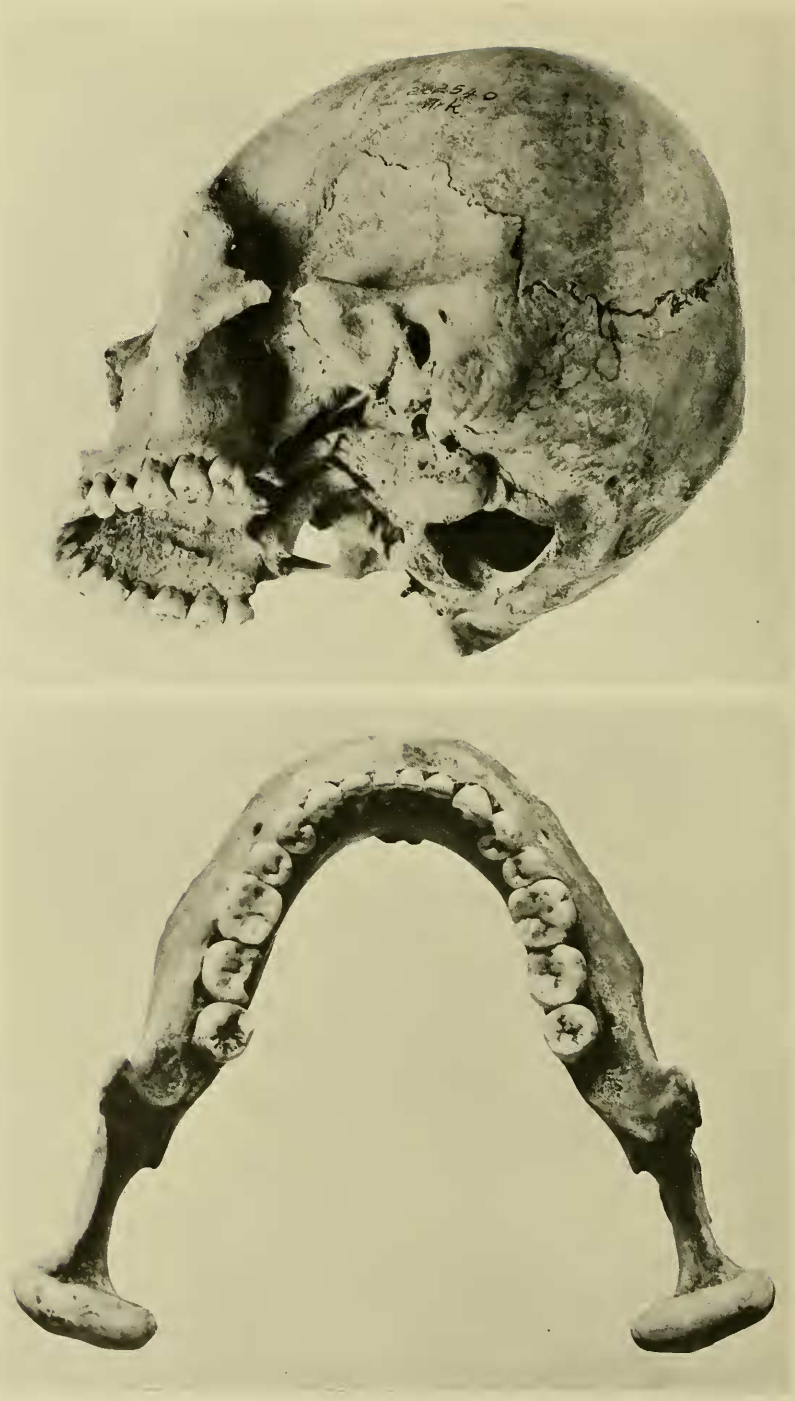
3

1 and 3, PAN SP. AFRICA (RECENT), $\times \frac{3}{4}$

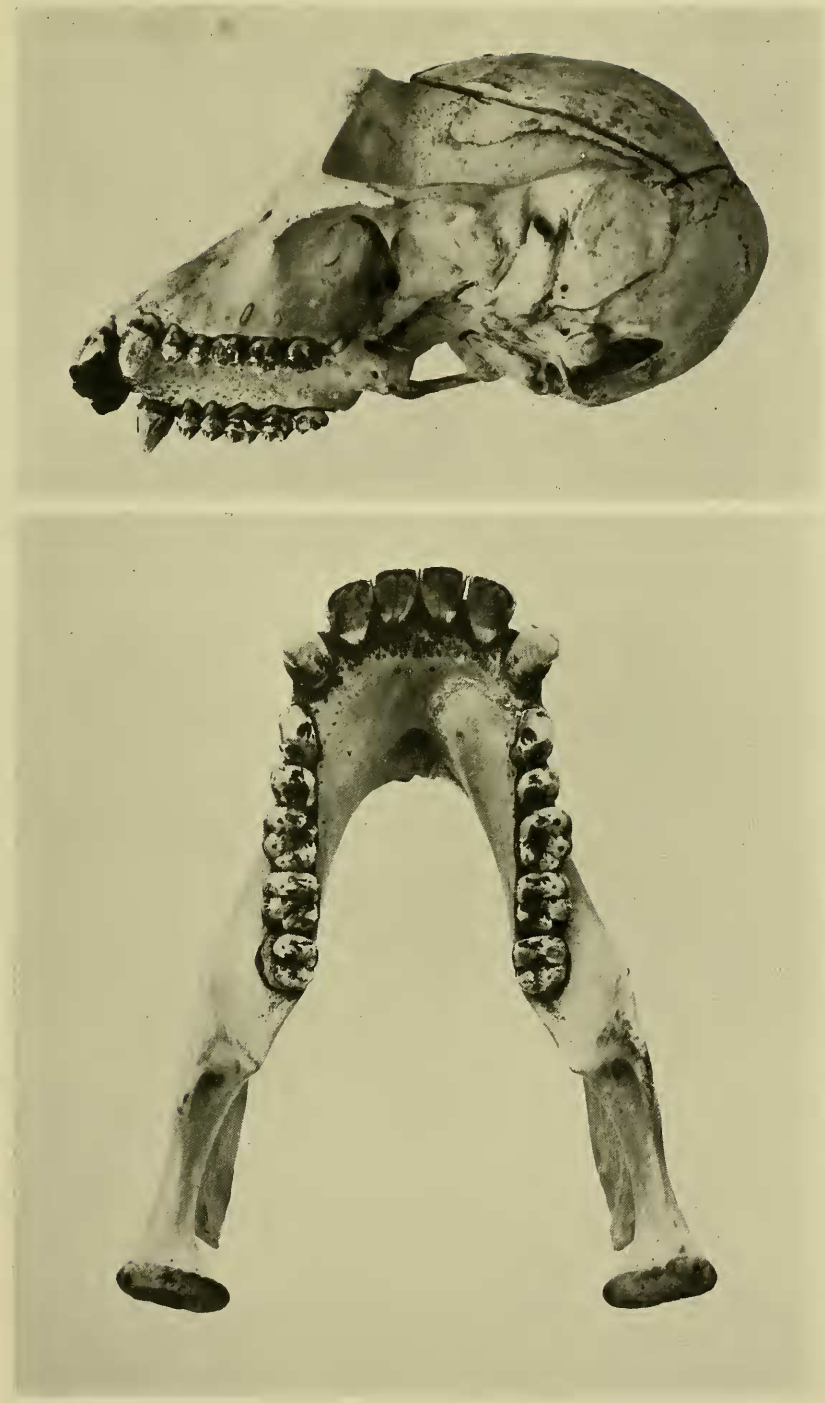
2, PAN VETUS. ENGLAND (PLEISTOCENE), $\times \frac{3}{4}$

The casts of the African specimens have been mutilated as nearly as possible in the same manner as the fossil

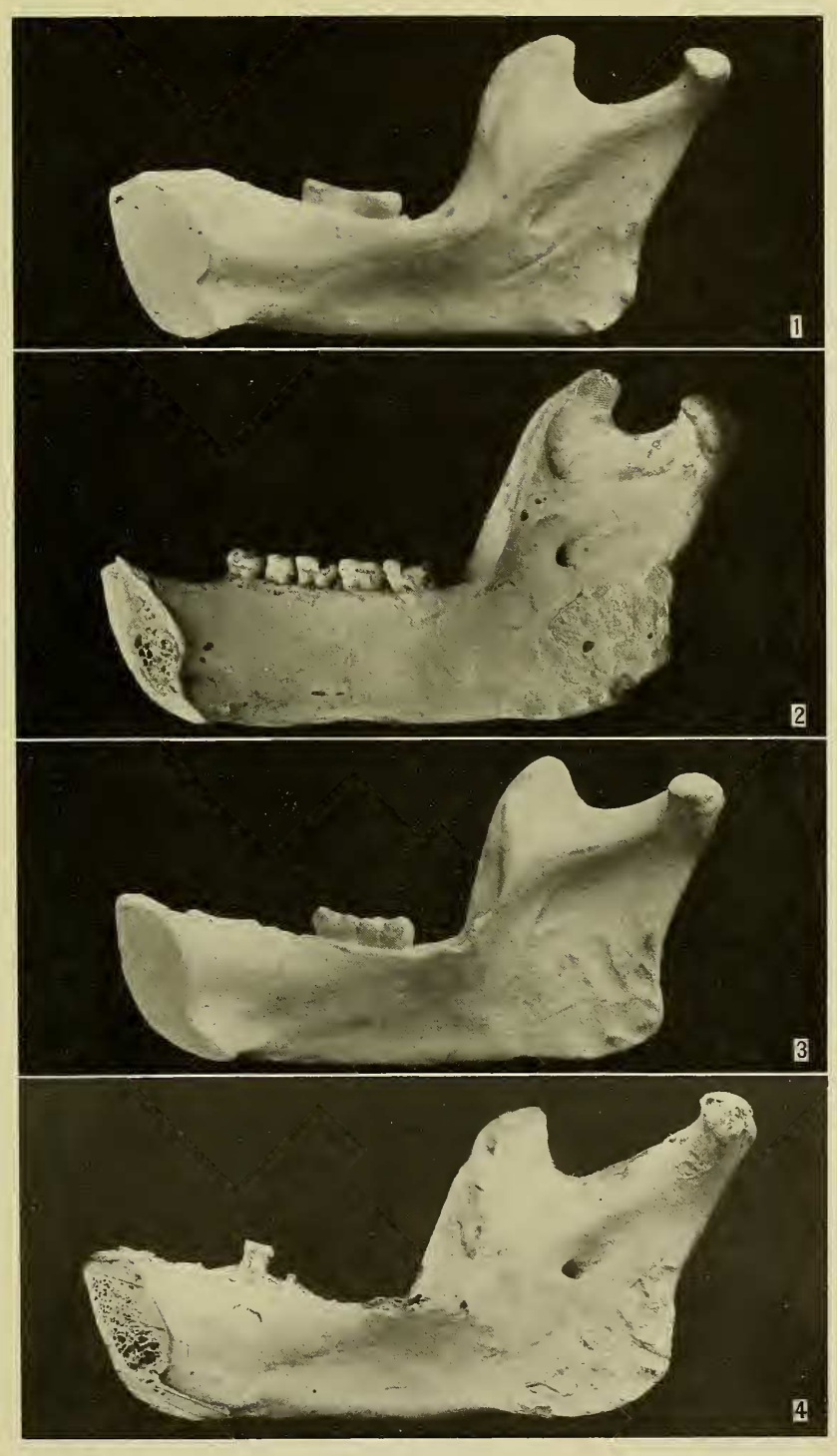
1, 3, and 4, PAN SP. AFRICA (RECENT), × ¾
2, PAN VETUS. ENGLAND (PLEISTOCENE), × ¾
The casts of the African specimens have been mutilated as nearly as possible in the same manner as the fossil



HOMO SP. (RECENT). SKULL GREATLY REDUCED, MANDIBLE × $\frac{3}{4}$
To show the association of cranial and mandibular characters normal in the Hominidæ



PAN SP. (RECENT) SKULL GREATLY REDUCED, MANDIBLE × ¾
To show the association of cranial and mandibular characters normal in the Pongidæ



PAN SPP. (RECENT), × $\frac{2}{3}$
To show variations in form of mandible